



NASA SBIR 2012 Phase I Solicitation

H3 Life Support and Habitation Systems

Life support and habitation encompasses the process technologies and equipment necessary to provide and maintain a livable environment within the pressurized cabin of crewed spacecraft. Functional areas of interest to this solicitation include atmosphere revitalization and particulate control, environmental monitoring and fire protection systems, crew accommodations, water recovery systems, solid waste management and thermal control. Technologies must be directed at long duration missions in microgravity, including Earth orbit and planetary transit. Requirements include operation in microgravity and compatibility with cabin atmospheres of up to 34% oxygen by volume and pressures ranging from 1 atmosphere to as low as 7.6 psi (52.4 kPa). Special emphasis is placed on developing technologies that will fill existing gaps, reduce requirements for consumables and other resources including mass, power, volume and crew time, and which will increase safety and reliability with respect to the state-of-the-art. Non-venting processes may be of interest for technologies that have future applicability to planetary protection. Results of a Phase I contract should demonstrate proof of concept and feasibility of the technical approach. A resulting Phase II contract should lead to development, evaluation and delivery of prototype hardware. Specific technologies of interest to this solicitation are addressed in each subtopic.

Subtopics

H3.01 Advanced Technologies for Atmosphere Revitalization

Lead Center: MSFC

Participating Center(s): ARC, GRC, JSC, KSC

Advancing process technologies for key atmosphere revitalization (AR) functions will be essential for enabling future efforts to extend crewed space exploration beyond low Earth orbit. Specific process technology advancements are sought in the technical areas of regenerative CO₂ removal, process gas drying, regenerable particulate matter filtration and separation techniques, and photocatalytic processes for removing trace volatile organic compounds (VOCs) from cabin atmospheric gases. Specifics pertaining to each technical area are the following:

- **Advanced Sorbents for CO₂ Removal** - Development of robust, high capacity, regenerable CO₂ adsorbents that substantially reduce the energy required for regeneration, are resistant to material degradation (i.e., dusting, spalling) and are highly selective to CO₂ over moisture. Candidate sorbents must be capable of operating in either CO₂ venting (open loop) or CO₂ processing (closed loop) modes.

- *Passive Moisture Removal* - Development of advanced water vapor removal techniques from air streams that operate at near-ambient pressure and temperatures and with little to no energy costs. This may include the development of water-selective materials (e.g., membranes, adsorbents) that exhibit significantly higher efficiencies than current commercial products. Very dry air (-65 °C dew point) can be assumed to be available to aid in drying process stream (1:1 ratio). Candidate process technologies must be capable of either venting moisture to space or returning moisture to the cabin for subsequent recovery for crew use.
- *Particulate Management* - Long-life and self-cleaning particulate pre-filters are required to reduce crew maintenance time and eliminate the need for consumable filter elements. These units should be able to handle large surges of particles and operate over very long periods. They should also be self-cleaning in-place or off-line (in-place is preferable, and provide viable methods for disposing of collected particulate matter while minimizing or eliminating direct contact by the crew. Complete (100%) capture of particles 20 microns and larger is required. Targeted technologies should be compact and lightweight, and easily integrated with the spacecraft Environmental Control and Life Support Systems (ECLSS).
- Photocatalytic Oxidation (PCO) for Trace Contaminant Control - Technologies are of interest for photocatalytic oxidation of Volatile Organic Carbon (VOCs) completely to CO₂ and H₂O (i.e., complete "mineralization") without producing partial oxidation products such as aldehydes and/or organic acids. Catalysts that are activated not only by UV, but also the visible region of the solar spectrum to capitalize on the highly efficient blue LEDs or solar energy are desired. Concepts should minimize PCO reactor volume via improved catalysts and catalyst activity, improved UV illumination scheme and/or improved illuminated catalyst surface area-to-volume ratio.

Technology Readiness Levels (TRL) of 2 to 3 or higher are sought.

Potential NASA Customers include:

- Mission elements and vehicles: Orion Multi-Purpose Crew Vehicle, Multi-Mission Space Exploration Vehicle, Deep Space Habitat, Pressurized Rovers and Planetary Surface Systems, International Space Station.
- Human exploration missions include: Low-Earth orbit, Earth's neighborhood (Earth-moon libration points, lunar orbit and surface, geosynchronous orbits, etc), Near-Earth Asteroids, Mars Missions (transit, orbit, moons and surface).

(<http://www.nasa.gov/exploration/home/index.html>)

H3.02 Environmental Monitoring and Fire Protection for Spacecraft Autonomy

Lead Center: JPL

Participating Center(s): ARC, GRC, JSC, KSC, MSFC

Environmental Monitoring

Technologies are desired to ensure that the chemical content of the air and water environment of the crew habitat falls within acceptable limits and the life support system is functioning properly and efficiently. Required technology characteristics include: 2 year shelf-life; functionality in microgravity and low pressure environments (~8 psi). The technologies require significant improvements in miniaturization, reliability, life-time, self-calibration, and reduction of expendables. Examples of desired analytes are:

- Trace silver (0.05-15 mg/L) and trace organics in water (acetone: 0.05-5 mg/L; aldehydes: 0.4-60 mg/L;

alcohols: 1-100 mg/L).

Technologies for quantification and identification of microbial species are requested within an alternative subtopic, ISS Utilization.

Spacecraft Fire Protection

A first response crew mask capable of protecting the crew from ammonia, hydrazine, and combustion products is desired. A suitable first response mask should be quick to don, protect the wearer from environmental contaminants and elevated temperature hazards, and provide breathable air during prolonged emergency response activities. This mask would be one-size fits all and be effective for a minimum of 1 hour. While wearing the mask, the crew should have excellent freedom of motion and positive indication of effectiveness.

A portable, self-contained fire and toxic atmosphere cleanup system is desired that can rapidly remove contaminants from a spacecraft volume

Technology Readiness Levels (TRL) of 3 to 4 or higher are sought.

H3.03 Crew Accommodations and Water Recovery for Long Duration Missions

Lead Center: JSC

Participating Center(s): ARC, KSC, MSFC

Spacecraft crew accommodations requires volumetrically reconfigurable and hygienic crew interiors that maintain crew productivity. Advancements are required to reduce logistical packaging mass residual, repurpose logistical items for outfitting, provide extended wear clothing, clothes laundering, and metabolic waste collection/processing. Advancements in technology for water recovery are required to exceed existing 85% recovery from urine and humidity condensate. It is expected that both the variety of wastewater sources and the total volume of wastewater will increase with increasing mission duration. Technologies that increase closure of the water system and reduce expendables will enable future missions. Specific focus areas include:

Human Fecal & Waste Management:

- Technology is needed to collect, dry, process, and recover useful materials, and to safely store human

feces, trash, and processed residuals. Technologies for micro-gravity collection of urine and feces should have modes that allow for operation even if active components fail, by relying on or being aided by passive processes for function, such as capillary forces. Minimal crew interaction, low energy, contamination tolerant waste processing systems that recover water, methane, or other useful materials are desired.

Logistical Repurposing:

- Novel alternatives to existing launch foam packaging materials that are light weight, have low frangibility, and can be compressed or heated to achieve low residual volume after launch.
- Launch packaging systems (bags, nets, hard structures) that can be repurposed or reconfigured on orbit to provide interior crew accommodations (sleep areas, exercise, hygiene, thermal/sound control) with minimal mass penalty.
- Logistical materials that can be readily processed or reformulated on orbit to provide atmospheric gases, water, or material for in-space fabrication processes with minimal power requirements.

Mixed Brine Water Recovery:

- Recovery of water from mixed waste stream brines with 12% or higher dissolved solids are desired. Low energy, microgravity, low expendable systems should be tolerant of urine stabilization chemicals such as oxone, sulfuric acid and hexavalent chromium.

Biocide Delivery Systems:

- Technologies to replace the use of iodine for potable water disinfection. This may include techniques to replenish silver ions to a concentration of 0.4 mg/l in potable water or techniques to minimize the loss of silver ions in a potable water system. In addition, alternative disinfection technologies to inhibit biofilm formation on surfaces and provide residual disinfectant to maintain potable water quality would be considered.

Technology Readiness Levels (TRL) of 3 or higher are sought.

Potential NASA Customers include:

- Mission elements and vehicles:

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- Orion Multi-Purpose Crew Vehicle.
 - Multi-Mission Space Exploration Vehicle.
 - Deep Space Habitat.
 - Pressurized Rovers and Planetary Surface Systems.
 - International Space Station.

Human exploration missions include:

- Low-Earth orbit, Earth's neighborhood (Earth-moon libration points, lunar orbit and surface, geosynchronous orbits, etc).
- Near-Earth Asteroids.
- Mars Missions (transit, orbit, moons and surface).

(<http://www.nasa.gov/exploration/home/index.html>)

H3.04 Thermal Control Systems

Lead Center: JSC

Participating Center(s): GRC, GSFC, JPL, KSC, LaRC, MSFC

Future human spacecraft will venture far beyond the relatively benign environment of low Earth orbit. They will transit through the deep space, but they may encounter warm transient environments such as low lunar orbit. Some spacecraft elements may be launched untended and would operate at relatively low power levels as they transit to their final destination. The combination of extreme environments and high turndown capability will be a major challenge for spacecraft Active Thermal Control Systems (ATCSs). Sophisticated thermal control systems will be required that can dissipate a wide range of heat loads in widely varying environments while using fewer of the limited spacecraft mass, volume and power resources. Advances are sought for microgravity room temperature thermal control in the areas of:

- Innovative thermal components and system architectures that are capable of operating over a wide range of heat loads in varying environments (for example, a 5:1 heat load range in environments ranging from 0 to 275 K).
- Two-phase heat transfer components and system architectures will allow the efficient acquisition, transport, and rejection of waste heat.

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- Heat rejection strategies and hardware for transient, cyclical applications - e. g., phase change material heat exchangers, heat pumps, or efficient evaporative heat sinks.
 - Smaller, lighter, high performance heat exchangers and coldplates.
 - Low temperature external working fluids (a temperature limit approaching 150K) with favorable thermophysical properties - e. g., high specific heat, high thermal conductivity, and viscosity that does not dramatically increase at lower temperatures.
 - Internal working fluids that are non-toxic, have favorable thermophysical properties, and are compatible with aluminum tubing (i.e., no corrosion for up to 10 years). Low temperature limits (~150 K) and favorable thermophysical properties would allow their use externally in a single loop ATCS.
 - Low mass, high conductance ratio thermal switches.
 - Long-life, light-weight, efficient single-phase pumps capable of producing relatively high pressure heads (~4 atm).
 - Variable area radiators (e.g., variable conductance heat pipe radiators or drainable radiators).
 - New thermal design tools to reduce the time and costs required for analysis, design, integration, and testing of the spacecraft. In particular, an innovative thermal design tool capable of fast and accurate spacecraft thermal modeling with significantly reduced effort and cost is needed.

Technology Readiness Levels (TRL) of 2 to 4 or higher are sought.

Potential NASA Customers include:

- Orion Multipurpose Crew Vehicle (http://www.nasa.gov/mission_pages/constellation/orion/index.html)

Future Human Space Missions - (<http://www.nasa.gov/exploration/home/index.html>)